MORE Technological Innovation in Amateur Radio

Zero Retries Newsletter

Steve Stroh N8GNJ

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What's with the name "Zero Retries"?

https://www.zeroretries.org/about#§frequently-asked-questions-about-zero-retries

- "Zero Retries" is a term from Amateur Radio Packet Radio
- When you transmit a "reliable" packet, a "checksum" is also transmitted
- The receiving station receives the packet (hopefully) and computes its own checksum from the received packet.
- If the checksums match, then the packet was received correctly.
- If the checksums don't match, then the receiving station requests a retransmission… a retry.
- Thus a transmission with "Zero Retries" is a good transmission.

N8GNJ Brief Intro

(Future page on Zero Retries)

- Live in Bellingham, Washington, “The City of Subdued Excitement”
  - Southern terminus of the Alaska State Ferry System
  - Famous from Freakonomics Radio for the Northernmost (*two*, now) Trader Joe’s
  - 20 miles from Canada border, 55 miles from Vancouver, British Columbia
- Licensed in 1985, so *forty years* now… wow… sounds *really* old
- For me, Amateur Radio got really interesting once you could do Packet Radio
  - Radio + Networking + Computers ***!!!***
- Learned a lot from a wild group in the Seattle area (The WETNET Mafia) area that built a network with 4x 9600 bps bit regenerative repeaters… running TCP/IP
- Big shop called N8GNJ / Zero Retries Labs, eventually to be the home of the Packet Radio Test Facility

Zero Retries Newsletter

https://www.zeroretries.org

- Free to subscribe! (Optional paid subscriptions are appreciated!)
- Tracks technological innovation happening in Amateur Radio…
  NOW!
- Explaining the *totality* of **how much** technological innovation
- Mission creep…
  - Lots of commenting in FCC Requests for Comments
  - Championing and explaining NewTechHams
  - Advocating for things we need in Amateur Radio (regulatory streamlining)

Three Guiding Quotes

https://www.zeroretries.org/about#§zero-retries-interesting-relevant-and-interesting-quotes

- Ultimately, amateur radio must prove that it is useful for society.

  Dr. Karl Meinzer DJ4ZC.

- The Universal Purpose of Ham Radio is to have fun messing around with radios.

  Bob Witte K0NR

- Irrational exuberance is basically the business model of Zero Retries.

  Steve Stroh N8GNJ

NewTechHams

(Future page on Zero Retries)

- Discovered this community of new Amateur Radio Operators in writing Zero Retries
  - Generally younger and involved in tech such as IT, software development, hackers makers, EE students. Example - DEF Con and GRCon attendees.
- Not recognized by mainstream Amateur Radio because
  - They don’t “advance” to General
  - They don’t participate in conventional Amateur Radio - DX, HF, voice chatting
  - They don’t attend / join Amateur Radio clubs
  - They don’t join big orgs like ARRL (no value proposition for them)

Why Tracking Technological Innovation *Matters*

(Future page on Zero Retries)

- *There will come a time…*
- *When it will be critical…*
- *To be able to fully document…*
- **Just how much Amateur Radio has contributed to innovation in radio technology.**

Why Encouraging Amateur Radio More Widely *Matters*

(Future page on Zero Retries)

- Modern society needs more radio technologists with hands-on experience
- Our communications infrastructure is radio technology
  - GNSS, Wi-Fi, Bluetooth, Mobile / Cellular, Satellite - Starlink, Kuiper, AST
- Ukraine has learned this viscerally. It’s not enough to just be a user of radio technology
- There’s no better training tool for hands-on experience with radio technology…
  - Than *Amateur Radio*

M17 Project

https://m17project.org/

- *Open source* digital voice and data system
- No proprietary technology
- Vocoder is Codec 2 (but doesn't have to be… remember it's an *open source* system)
- Full ecosystem of devices, including repeaters and now radios (off the shelf) - Connect Systems CS7000 M17 portable radio
- Includes data
- Extensible - experimental digital signing of each transmission
- Bringing in new Hams that *really care* about Open Source
- Now under new management (guidance) - M17 Foundation

Rhizomatica Mercury

https://github.com/Rhizomatica/mercury

- Open source equivalent of VARA HF
- Work in progress - not as full featured as VARA HF
- Designed as part of a system, including a designed-for-purpose radio and a protocol / application stack
- Mercury is an answer to those who bemoan that proprietary VARA HF is so dominant on Amateur Radio HF…
  - But if we want to see it fully featured on Amateur Radio, we have to get involved and help them finish it for Amateur Radio requirements

Opulent Voice

https://www.openresearch.institute/opv/

- Project of Open Research Institute
- Open Source, of course
- High quality digital voice taking advantage of higher bandwidth data modes
- Can interleave data and voice seamlessly
  - ***Finally!!! (Glad someone finally did this right… It's… just… bits!)***
- One of the coolest things is that it wasn't implemented in hardware… just software that runs on a Analog Devices ADALM-PLUTO (low cost Software Designed Transceiver designed for EE students) - 70 MHz to 6.0 GHz (hacked)

VARA FM + VarAC

https://rosmodem.wordpress.com/ **https://www.varac-hamradio.com/**

- Not just for EMCOM / Winlink
- Can use any VHF / UHF radio and audio interface to do 12 kbps
- With a flat audio radio and high fidelity audio interface can do ***25 kbps***
- Modern data - Forward Error Correction, upshift / downshift, OFDM
- Wide area networking via VARA FM digipeater or FM repeater
- VarAC adds email, file transfer, bulletins, text chatting
- Combination makes for a Local Area Communications Network

Hailing Channel for Packet Radio

(Future page on Zero Retries)

- WB4APR's original concept for broadcasting pointers to local resources
- We really need a hailing channel as we develop and deploy more modes / infrastructure
- Example (just my idea), broadcast a DMR codeplug
  - Hailing channel says codeplug file flood is on 440.123
  - DMR radios then change to 440.123
  - File flood transmitter (or repeater in the wee hours) transmits blocks of the cqodeplug file

AREDN

https://www.arednmesh.org/

- Repurpose Wi-Fi and Wireless Internet Service Provider microwave networking hardware with new firmware
- Unique requirements of Amateur Radio such as callsign and no encryption
- Plug and play mesh networking, handles “fussy bits” like:
  - DHCP assigns IP addresses, etc.
  - Mesh networking that really does “just work
- In 2025, switched to Babal networking protocol - much better meshing now
- Now can use 902-928 MHz band via 802.11ah / Wi-Fi HaLow

MMDVM-TNC

https://github.com/g4klx/MMDVM-TNC

- At present it's a concept to do higher speed data using existing MMDVM hardware
- Uses same robust waveform as DMR
- Uses modem technology of robust G3RUH 9600 bps (used for satellite)
- Implements Interleaved Layer 2 Protocol Forward Error Correction
- Various data modes including 19200 bps with FEC
- Embedding MMDVM in FM repeater, we can do *data* repeaters
- (Post presentation note - Going forward, will [probably] be called GTDATA)

IP400 Network Project

https://ip400.adrcs.org/

- ***I***ntelligent ***P***rotocol on ***400*** MHz band
- Takes advantage of *data communications* radio chipsets
- Higher speeds, starting at 100 kbps
- Operates on 70cm band, not microwave
- Will have built-in mesh networking
- Interoperates with other networks / protocols using encapsulation (wrappers)
  - TCP/IP v4, AX.25

Modern Packet Radio

https://en.wikipedia.org/wiki/KISS_(amateur_radio_protocol) https://tarpn.net/t/nino-tnc/nino-tnc.html https://www.rpc-electronics.com/smtninotnc.php
https://github.com/wb2osz/direwolf https://tarpn.net/t/il2p/il2p.html https://en.wikipedia.org/wiki/FX.25_Forward_Error_Correction

- KISS only - move protocol / network into to host computer
- Can run variable speeds - 2400, 4800, 9600, 19200
- New TNCs - NinoTNC (KISS), Dire Wolf
- DIre Wolf implemented internal bit flip error recovery when CRC errors
- What makes these faster packet radio practical is Forward Error Correction
  - ~~Interleaved~~ *Improved* Layer 2 Protocol (NinoTNC, Dire Wolf)
  - FX.25 (Dire Wolf) - backwards compatible with AX.25

New Packet Radio

https://hackaday.io/project/164092-npr-new-packet-radio
https://www.ardc.net/apply/grants/2024-grants/grant-new-packet-radio-version-3-0-seeding-uk-and-ireland-usage/

- No commonality with AX.25 Packet Radio
- Designed by Amateur Radio Operators for Amateur Radio
- High speed data only mode based on TCP/IP with Ethernet interface
- 100 kbps in a 100 kHz channel / 1 Mbps in a 1 MHz channel
- Hopefully FCC will delete symbol rates and bandwidth limits on VHF / UHF as many requested in FCC Docket 16-239 followup
- Grant from ARDC is extending NPR to 2 meters and 23 cm

GEO Satellite for Western Hemisphere

(Future page on Zero Retries)

- Serious case of QO-100 envy; geosynchronous Amateur Radio payload above Africa, Europe and much of Asia
  - 2.4 GHz uplink, 10 GHz downlink
  - QO-100 is driving all kinds of interesting experimenting - new radios, new modes,
- European Space Agency (ESA) has put out request for proposals for another GEO Amateur Radio payload (or small satellite) that would at least partially cover Canada (who is an ESA member country) and partial coverage of US
- open.space at Pacificon 2025 might be ideal 5 GHz uplink to an AR GEO

902-928 MHz (33cm) Band

(Future page on Zero Retries)

https://en.wikipedia.org/wiki/33-centimeter_band

- Hams have overlapping privileges with unlicensed (Part 15) users
- Fair number of analog FM repeaters, noise is less at band edges
- FCC Docket 24-240, NextNav proposes privatizing 15 MHz of the band and pushing Amateur and all Part 15 into 11 MHz in the middle of the band.
  - Lots of pushback! Automatic toll collection, RFID tags in retail, building automation, automatic meter reading
  - A *lot* of pushback from Meshtastic users and Amateur Radio (including Zero Retries)
  - 902-928 MHz is getting more interesting for data - new standard drove new hardware - 802.11ah / HaLow (now supported in AREDN)

219-220 MHz (1.25m) Band

(Future page on Zero Retries)
https://www.openresearch.institute/tag/219mhz/

- Consolation prize for removal of 220-222 MHz from Amateur Radio in 1988
- Must be point to point, divided into 10x 100 kHz channels
- “Mother, May I?” sharing (permission from commercial users)
- Incredibly muddled over the past decades - different services, leased out
- Never did actually get used - *for nearly four decades now!*
- Open Research Institute started a project for regulatory changes to make it usable, will eventually submit petition to FCC - ***Kudos!***
- What we really need is building some demonstration links to operate with a Spectial Temporary Authority or Part 5 Experimental license as proof of concept

Digital Amateur Television (DATV)

(Future page on Zero Retries)

- Full motion, good image quality in 2 MHz, based on open specification for satellite digital television
- Kind of a stealth mode in Amateur Radio
- DATV can be received with an inexpensive USB Software defined receiver
- Idea - Every metro area ought to have a DATV repeater; could be streaming videos about Amateur Radio - *on Amateur Radio*

ka9q-radio

https://github.com/ka9q/ka9q-radio https://ka9q-radio.org/ https://github.com/fventuri/ka9q-web

- ka9q-radio is software that runs on a host computer that takes the entire bandwidth of a software defined receiver and parses out individual radio channels - all of them, simultaneously
  - Not typical sequential scanning
- Example - can monitor and record all 2m (144-148 MHz) repeater and simplex channels
- Recent development is ka9q-web which puts a graphical user interface on ka9q-radio

KK7NQN Transcriber Service Node

https://kk7nqn.net/

- First public discussion at Zero Retries Digital Conference 2025
  - We’re very proud!
- Open source project
- Transcribes conversations on repeaters, including parsing callsigns
- Does not use public services - runs on dedicated user device
- Is continually being extended including being able to “listen” for your callsign (N8GNJ) or specific phrases (packet radio) and send a notification.

Communication and Telemetry System (CATS)

https://cats.radio

- Next generation idea for doing APRS
- Operates on 440 MHz instead of 144.39 MHz
- Operates at 9600 bps instead of 1200 bps
- Uses raw Frequency Shift Keying instead of Audio Frequency Shift Keying
- Transmits with Forward Error Correction - typical APRS does not have FEC
- Keeping with the “cat” theme, the Internet infrastructure is called FELINET
- More info at cats.radio

Meshtastic for Amateur Radio

(Future page on Zero Retries)

- Energy / adoption going into Meshtastic is amazing
- Evidence that experimenting with radio technology is of interest to the (techie) public
- One of the big lessons learned is low price to experiment is critical (<$100)
- Meshtastic is re-learning lessons we learned from Packet Radio networking era
  - Example - single channel networking (digipeaters) don’t scale well
- MeshCore is gaining popularity as an alternative - Meshtastic that works

File / Bulletin Flood Protocol

(Future page on Zero Retries)
https://www.w1hkj.org/files/manuals/US_English/FLAmp_2.2_Users_Manual.pdf

- Whatever you do, *don't utter the (other) "B" word…*
  - Remember, you're transmitting bulletins, *bulletins*, **bulletins**!
- Old, deprecated implemation called RadioMirror (DOS era, IIRC)
- Current implementation is flamp - part of the fldigi suite of apps
  - **F**ast **L**ight **A**mateur **M**ulticast **P**rotocol
- Continuously transmits series of file blocks with checksum
- Checksum matches, add to the file
- When all blocks are received, file is saved
- Just keeps transmitting… *bulletins* - code plugs, club bulletins, Zero Retries
- Imagine how powerful this is with faster data speeds and Forward Error Correction

ARDC - Venture Funding and 44Net

https://www.ardc.net/apply/https://wiki.ampr.org/wiki/Main_Page

- Amateur Radio Digital Communications… but not exclusively Amateur Radio or Digital Communications
- Predecessor of ARDC obtained a Class A IPv4 address block - 16M IPv4 addresses
- Eventually sold 25% - 4M IPv4 addresses to create an endowment
- Now award grants of $5M+ annually
- Fund many new technology development such as MMDVM, M17, FreeDV
- Remaining 12M IPv4 addresses is called 44Net
- ARDC is beta testing a free 44Net VPN - https://dashboard.44net.cloud/

Software Defined Radio

https://en.wikipedia.org/wiki/Software-defined_radio

- You can specify *exactly* what you want the waveform to be - bandwidth, modulation, etc.
- *Hams are back in the technological innovation game* now that we can innovate in *software*
- Best example was a mention of “I needed a different radio, so I sat down and wrote one”
- Hardware is capable and easy and cheap for HF because frequencies are 50 MHz and lower.
- Software Defined Receivers for VHF / UHF is a solved problem
  - We’re not there yet for VHF / UHF SDR, at least for transmitting at reasonable power

GNU Radio

https://www.gnuradio.org/ **https://github.com/gnuradio/gnuradio-companion**

- GNU Radio is a software framework between Software Defined Radio hardware and applications
  - Kind of like Linux operates between a PC and Linux apps
- Huge number of “write a radio” applications called flow graphs
- One example is there is a flow graph for LoRa, so we can start hacking on LoRa - Chirp Spread Spectrum
- Training wheels graphical user interface called GNU Radio Companion
- More than half of attendees at GNU Radio Conference 2025 were hams

Pushing The Envelope - LinHT

https://github.com/M17-Project/LinHT-hw

- **Lin**ux **H**andie **T**alkie
- Created from M17 Project
- Open source user modifiable SDR as a handheld radio
- Brilliant hack to make it practical - hijack a Chinese handheld radio
- Working prototype - UHF only, low power (amp being developed)
- Runs real Linux on device (shell into your portable), runs GNU Radio *on device*
- Eventually Chinese vendors will spot this opportunity to sell LinHT for 2x or 3x the price of a generic FM VHF / UHF radio

Pushing The Envelope - SuperPeater

(Future page on Zero Retries)

- My concept - and only a concept
- Primary idea is the transmit is a high bandwidth data waveform
  - Receiver is a Software Defined Receiver with a cheap computer
- Secondary technology is ka9q-radio receiver - simultaneous inputs
- Multiple input types such as 1200, 9600 packet, MMDVM-TNC, VARA FM
- With transmit and receive decoupled, can do cross band

Pushing The Envelope - Single Channel Repeater

(Future page on Zero Retries)

- Some DMR vendors have created single channel repeaters
- “Hack” DMR to use Time Slot 1 as receive, Time Slot 2 as transmit
- No duplexer needed
- No need to coordinate repeater channels
- Much easier to deploy repeater infrastucture - let 1000s repeaters bloom
- Idea isn’t exclusive to DMR - generic idea is Time Division Multiple Access

Pushing The Envelope - Secret Innovation Weapons

(Future page on Zero Retries)

- FCC §97.309(a)(4) RTTY and data emission codes
- An amateur station may transmit a RTTY or data emission using an unspecified digital code, provided that the technical characteristics of the emission are publicly documented.
- So basically we can do anything within the general framework - non-commercial, non-encrypted, within Amateur Radio allocations
- For the things that are blatantly out of scope, we can do Special Temporary Authority (STA) or a Part 5 Experimental License
- Example - IP400 going faster might require more than 100 kHz on 420-450 MHz
- Generally, “ask for forgiveness rather than ask for permission”
- In Canada “Just do your thing and try not to bother the regulators”

Zero Retries Digital Conference

https://www.zeroretries.org/p/conference

- TAPR is no longer doing (national) Digital Communications Conferences
- Tina KD7WSF and I decided that we should do a Zero Retries version of DCC
- GNU Radio Conference was held September 8-12 in Everett, WA
- Great venue, we decided to hold ZRDC 2025 on Saturday September 13
- Invited highly targeted presentations that demonstrated technological innovation in Amateur Radio
- ***It Was Great!!!***
- Yes, there will almost certainly be a ZRDC 2026 (but no details quite yet)

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https://www.zeroretries.org/about

www.zeroretries.org

- Substack will “encourage” you to select a paid subscription, but just pick the free one.
- Paid subscriptions are appreciated, and help keep Zero Retries going, but not required.
- Publishes every Friday at 15:30 Pacific… usually
- Feel free to email me with ideas - editor@zeroretries.net

Questions?